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ABSTRACT

The development of a computer-based, university-wide testing system at Brigham Young University is discussed, as is its application to two large-enrollment math classes. The hardware configuration, software applications, general philosophy, budget, and personnel requirements of the system are also explained. Development of the system over time is explained as is the flow of students and faculty through the system. The organization of the two math courses is described and the philosophy and constraints which molded the classes into their present management structure are explained. The interaction between the testing system and the students is analyzed, and problems of the course co-ordinators concerning the testing system are discussed. The results of the interaction between the system and the math classes is treated and comments are made regarding the advantages and disadvantages of such an interaction. (Author/GK)

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THE ROLE OF A COMPUTER BASED UNIVERSITY-WIDE TESTING SERVICE IN THE MANAGEMENT OF LARGE ENROLLMENT COURSES

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THE ROLE OF A COMPUTER BASED UNIVERSITY-WIDE TESTING SERVICE IN THE MANAGEMENT OF LARGE ENROLLMENT COURSES

At Brigham Young University, the computer based university-wide testing service has come to serve as a major resource in the development of large enrollment classes. In fact, it has become indispensible as a source of solutions to problems encountered in the growth and progress of such systems. This paper will describe the computer-based testing system on this campus. Then, using as examples two mathematics programs, will discuss in detail how this system can relate to course testing and management for very large enrollment courses. Since these courses have a combined enrollment of about 4,000 students and together write nearly 35,000 tests per semester, they have provided both the respective coordinators and the testing system with ample problems and situations for research and development.

Development and General Description of SCOUT

Development

Testing Services (TST) at Brigham Young University (BYU) was organized in the late 1950's to provide psychological and vocational test support services to the Counseling Center. By 1966, the system was providing general test scoring services to the entire university. In 1971, the developers of this system felt that if faculty members could have the option of testing their students outside of normal lecture hours, more hours could be devoted to instructional purposes and so began the service of providing out-of-class computer assisted testing.

TST management, with University administration support, thus began a systems analysis which culminated in the development of an entirely new method of test processing at BYU--SCOUT (System for Computer-assisted On-line University-wide Testing).

Hardware Configuration

SCOUT is supported by a 64K, 50 megabyte Microdata minicomputer. Attached to the mini are ten ADDS video display terminals each equipped with a Monarch 2246 barcode reader. An NCS 7001 optical scanner is backed up, off-line, by an NCS 7005 optical scanner. Completing the system are a Centronics 6600 upper/lower case system line printer, a Printronix 300 lpm matrix printer, and a 9-track, 800 bpi tape drive. Hardware costs totaled approximately $100,000. SCOUT is written in an extended version of BASIC. The system took about twelve man-months of labor to design, code, de-bug, and put into operation.

Staff, Budget, and Volume

The Testing Center is housed on the main floor of the University's Harold B. Lee Library. It occupies approximately 6,000 square feet of floor space. It is staffed by three full-time administrative/staff personnel and 25-30 part-time student employees. The facility is open 12 hours per day Monday-Friday and four hours on Saturday.

The Center operates on an annual $200,000 budget and is self-supporting in as much as academic departments and students are charged for tests administered.

Since the implementation of SCOUT on August 26, 1976, over 1,200,000 tests have been administered. The current volume is more than 300,000 tests per year serving 260 different classes ranging in size from 25 to 2,500 students.

General Description of Services

There are several standard services offered by the Testing Center, variations of which can be chosen by program coordinators or instructors for their classes.

Class Initialization

Class Initialization is the method by which the Testing Center is able to create a class roll for each class requesting testing services. At the beginning of a semester, before the first student comes into the Testing Center, the course instructor or coordinator submits to Testing Services a list of testing periods. Also provided is test weight information, telling SCOUT how a particular test is to count in relation to all other tests given for the course during the semester. The instructor may request a retake option. If students are permitted to retake an examination, the instructor decides which score will count in assigning a grade (either the last score or the best score). Options of assigning letter grades, penalizing incorrect answers, subtracting a penalty for late tests, etc, are available. The instructor also decides what type of test feedback information is to be reported to the student.

The first step in creating a file is to access the University's "Student Information System" on BYU's IBM 4341 computer and obtain a tape of all students currently enrolled at the University. This tape also provides a list of each student's current class registration. The tape is then used to initialize SCOUT class files. If a student enrolls late and is not included on the class roll when it is tapped, he can be added when he takes his first test. The class tap helps to eliminate ID errors and to speed up student entry at the first of the semester and gives course personnel an accurate class list. As soon as the tap is completed, SCOUT is ready for the class members to begin their testing.

Student Entry

During the indicated testing period, the student comes into the Testing Center. Using the Monarch 2246, a barcode label on the back of the student's University ID is "read" and SCOUT responds indicating that the student is identified.

The Testing Center employee scans the appropriate barcode label in the test identification book telling SCOUT which test the student wants and the system responds by randomly assigning a form of the test to be administered. The appropriate examination is then issued. At this time, before entry is cleared, SCOUT automatically checks the student's files for class enrollment. In the case of a retake exam, the SCOUT assesses the appropriate fee and then checks to make sure the assigned form of the test has not been previously taken. The test deadline is also verified to assure that the student is within the authorized time period, and if not, a penalty for late tests can be imposed or entry can be denied. A "hold file" is checked to see if the student's file is flagged, and SCOUT refuses student entry until all the flags are cleared. These flags can be activated for various reasons--money owed, messages from the instructor, violation of the University's regulations, etc. TST management can also flag a student if any problems exist on his cumulative test file.

As soon as entry is cleared, the student with his exam and answer sheet is admitted to the testing area. This entry and clearance process normally takes from six to fifteen seconds, depending on the student and the test he is taking. Once the student is inside the testing area, SCOUT allows monitoring so that management has a count of all students in the system; as well as name, ID, test taken, and all other particulars about each student.

Test Scoring and Student Reports

When the student has finished his exam, he brings it to the scoring table.

Here a proctor puts the answer sheet into an optical scanner. The answer sheet barcode number as well as student answers are transmitted to the Microdata for scoring. SCOUT's scoring program identifies the student from the answer sheet ID, selects the appropriate key to score the test, and then posts the results in the student's cumulative file. The program also transmits to the printer the student's name, social security number, raw score, percent score, letter grade, class information, etc. At the instructor's option, the program can also provide additional information such as: (1) a list of the items the student missed; (2) the student's responses to the questions; and (3) the correct answers. It can also compute specific area scores within the test, thus indicating explicitly areas of student weakness. This process of scoring, posting and reporting, is completed in about twelve seconds. The student exits with a hard copy of his exam results.

If the student loses his report, or if he wants a cumulative report, SCOUT can reprint his original report or produce a report listing all tests taken for all classes on the system in which he is enrolled.

On-line Cumulative Faculty Reports

As soon as SCOUT's scoring program has posted the score to the student's cumulative file, this file can be reported to the instructor. Generally, but not necessarily, these faculty cumulative reports run at night after the office is closed, and are thus ready the next morning. These reports can be alphabetic by class section or alphabetic overall (all sections combined). They can also be printed in social security number order without names for posting purposes.

The format for the cumulative faculty report lists percent, total points, and can assign a cumulative letter grade in addition to listing student scores on each exam. For each exam, mean scores, standard deviations, medians, modes, and scoring ranges are printed. Depending upon the option chosen when the class

was initialized, the reported score on a particular exam can be either the student's best or his last score. The instructor can even change this option and get reports both ways if desired, thus allowing measurement of student progress on retake exams.

In addition to the grading features just listed, an item analysis is provided on each test item giving frequency of response, percentage of students answering each response, and a co-efficient of selective efficiency to determine item discrimination. Score distribution means, modes, medians, standard deviations, kurtosis, skew, and other statistical measures are also provided to facilitate a more complete analysis of each test.

Grades Transmission

Traditionally, at BYU, instructors have had the responsibility of assigning a student's semester grade, coding a grade roll, and submitting that grade roll to the Records Office. That office in turn brings the rolls to Testing Services to be optically scanned and sent to Computer Services for processing and posting to the student's transcript. Inasmuch as Testing Services already had the SCOUT test data in machine readable form at the conclusion of the semester, a new module was added to the system at the Math Department's request, to allow instructors the option of transmitting their grades directly. This bypasses the somewhat cumbersome and error-prone grade roll procedure and saves the instructor many hours of tedious semester-end work.

Testing Services and the Growth of Two Large-Enrollment Math Courses

The two courses to be displayed make up roughly 33% of Testing Center business. These courses began about five years ago to experience phenomenal growth. As the numbers of students began to grow, the systems began to be strained. These two courses presently serve about 4,500 students per semester.

Most of the students are pursuing majors outside mathematics. There is a rather limited tenured faculty involvement at this level and a small graduate program in math does not provide the number of graduate students needed to serve the needs of such large enrollment courses. Special management designs were needed because of the large enrollments and instructor limitation. This led to the creation of some flexible, but very stable, systems in which instructors can enter and exit without destroying the continuity of student progress from one semester to another. The instructor's concern is with content and presentation rather than course management, testing, etc.

The courses served by these systems are (1) Basic Math Review, which is a remedial course preparatory to the Basic Math Skills Evaluation required as a part of the University's General Education program; and (2) College Algebra/ Trig, which is a calculus preparatory course, but is also terminal for many. For both of these programs, a mastery learning format was chosen. Multiple form testing is used with feedback available after each test attempt. The students are strictly paced as they proceed through the course material. Grades in both courses are assigned against fixed scales.

Math 100D - Organization of the Course

Math 100D covers the basic mathematical skills and applications needed to pass the General Education Evaluation (known hereafter as the G.E. exam). The course will provide students with:

1. A review of applied arithmetic skills involving percentages and statistical graphs.
2. A review of common geometric figures and measurement formulas and an introduction to the metric system.
3. An introduction to basic principles and skills in working with algebraic expressions and equations.
4. Experience in applying arithmetic and algebraic skills to interpreting and solving verbal problems.

There is an especially heavy emphasis on verbal problem solving skills. This emphasis is consistent with the goals of the general education experience.

The course material is organized into eight (8) study units, each of which is followed by an examination. In addition, the G.E. examination serves as a comprehensive final.

For most students in this course, there are no lectures given and there will be no formal class period assigned. Instead, the high support component of this course offers students the support and resources to meet the needs of their individual learning process.

Math 110 - Organization of the Course

Math 110 is the precalculus mathematics experience. It contains material often described as college algebra and trigonometry plus some additional topics. It is organized into eight (8) individually taught and graded mini-courses on modules:

100F	A Review of Fundamentals	1.0
110A	Polynomial and Rational Functions	1.0
110B	Exponential and Logarithmic Functions	0.5
110C	Matrices and Systems of Linear Equations	0.5
110D	Combinatorics	0.5
110E	Linear Programming	0.5
111A	Trigonometry	2.0
111B	Coordinate Geometry	0.5

A specific sequence of modules arranged for presentation during the semester at a fixed hour in a given room is called a track. A track schedule, a description of the current semester's offering of modules listed in tracks, is available to each student and in the math lab.

A student registers for Math 110 for a variable credit of at least two (2) hours (unless permission is given by the program director). After attending a first day orientation, he determines which modules in which tracks he wishes to attend. The student indicates this initial program through an initialization

procedure during the first days of the semester. If the student later wishes to change this initial program, he may do so up to the date posted for finalization of all Math 110 programs. Note that at no time may a student drop Math 110 without going through the official university drop procedure nor may a student change his program to less than two (2) credit hours in Math 110.

A student's grade in a particular module is determined by the score attained on an examination covering the material in that module. The student has the opportunity to be re-examined twice over the module at his expense but all examinations over a particular module in a particular track must be completed by the date posted in the current track schedule.

Specific Course Problems and Concerns

Math 100D

Enrollment

Early in the development of the Math 100D program, students enrolled in the course through regular registration, but enrolled at the Testing Center by taking their first exam. This caused some differences to occur between the University class roll and the roll reported from the Testing Center. In addition, the Testing roll also continued to carry the names of students who had dropped the class after taking one or more exams. By the end of the semester, these differences in the rolls were the source of confusion and concern for the instructors. Implementation of the class tap procedures in 1978 provided instructors not only with current student progress, but also with current course registration information that was consistend with University rolls.

Testing

All testing for Math 100D takes place in the Testing Center. This allows the student to choose a testing time when he is prepared and when it is convenient

for him to spend the necessary time. The program provided by SCOUT paces the students through nine exams according to a schedule provided by the course coordinator. The SCOUT system keeps track of who has tested, how many times each student has tried each exam, and records the results of each student's best try for instructor inspection. Since about 17,000 tests are processed each semester for Math 100D, this tracking and recording service saves hours of instructor time which can then be used for tutorial, counseling, or development purposes which are critical in large enrollment courses.

In addition to the giant bookkeeping assistance, however, the Testing Center director and his staff have played a major roll in helping the course developers and coordinators to streamline the testing process so that students can test as quickly and smoothly as possible. Their suggestions and assistance in problem solving have been major keys to the success of system changes.

Grading

Early in the history of Math 100D, the computer assigned all grades except those altered by instructor decision. Recording of final grades for submission to Records was done by hand marking grade rolls. This process was laborious and exceptionally prone to human errors. Incorporation of the grades transmission feature of SCOUT relieved both the labor and the errors of the grading process. With Math 100D population at about 1,500 students per semester, the relatively error-free submission of grades saves an enormous amount of beginning-of-semester grade change hassle.

Evaluation

One of the strongest developmental supports offered by the SCOUT system and the Testing Center is its ability to provide data and data interpretation for program evaluation purposes. Math 100D is populated with students with a wide

range of abilities and special needs. In order to serve them well, areas of weakness in the system must be identified and strengthened. SCOUT has provided information about the relative difficulty of our exams. It has helped to identify bad questions or questioning techniques. The system has assisted in surveying student attitudes toward a particular part of the management system or study materials. Student information such as the relationship between ACT scores and student success has helped in our counseling efforts. Together, the Center and course coordinator have identified and developed tentative solution possibilities with great regularity.

Math 110

Enrollment

Because of the special nature of Math 110 enrollment, computer assistance is extremely helpful. In Math 110, 2,400 students enroll through usual registration. These students are then distributed into 10,000 modules which translates to a 10,000 student load by the process of initialization. The Testing Center scans and records all the initialization forms. Later in the term when each student has stabilized his program, he can retain his initial program or he may change his program by finalizing. Again, the Testing Center scans and records this new information into a final program roll which is then submitted to registration for printing of grade rolls.

Testing

Students in Math 110 accumulate about 15,000 tests during a semester. This includes 10,000 first takes of each module final and about 5,000 retakes. SCOUT keeps track of student testing, paces the student according to testing intervals and allows him within these intervals to try each exam three times. A special feature of the Math 110 program is that it actually paces the student

with two sets of deadlines--an initial or "bonus" period and a final deadline. If the student takes and passes the test on or before the initial deadline, he receives a half grade step bonus (B to B+, etc.) for that test. This bonus then follows the student on any retake of that exam he chooses to write. The student may also change his testing date deadlines by changing tracks. SCOUT contains student track information from initialization so the track can be changed by using a special form from which information is typed into the system by a terminal operator.

Grading

The computer chooses the highest letter grade from each module for which the student is registered and records the grade for transmission to records. The utilization of the grades transmission package in SCOUT is even more valuable in this course than for Math 100D. As was previously mentioned, even though the population of Math 110 is about 2,400 students, because each student is graded for an average of four modules, close to 10,000 grades are submitted. Before the direct grades transmission was used, the human error factor here was phenomenal. That problem has been reduced to a small, easy to handle a number of grade problems.

Results

The Department of Mathematics, in spite of the expense, are in support of the importance of continued involvement and research in the computer assisted areas of the two math systems described. Early in the mutual involvement between Math 100D - Math 110 and Testing Services, survival was the main impetus. The use of SCOUT centered around bookkeeping and flexible testing hours. Now that instructors have more time and energy available to look critically at their programs, the much more powerful nature of the system such as for evaluation efforts has become a welcome part of the experience.